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THE CHAETOTAXY OF NORTH AMERICAN LEPIDOCYRTUS S. STR., (COLLEMBOLA: ENTOMOBRYIDAE)

By Richard J. Snider

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THE CHAETOTAXY OF NORTH AMERICAN

LEPIDOCYRTUS S. STR., (COLLEMBOLA: ENTOMOBRYIDAE)*

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INTRODUCTION

The genus Lepidocyrtus Bourlet is a member of the tribe Lepidocyrtini which includes: Pseudosinella, Seira, and Heteromurus.

The genera listed above are very closely related and are often separated on the basis of presence or absence of eyes, falcate or toothed mucro, and whether or not the 4th antennal segment is simple or annulate. In former works members of the Lepidocyrtini were sometimes included under the genus Lepidocyrtus. Recognition of the North American genera as separate entities was done by Mills (1933). In the United States the genus Lepidocyrtus is recognized by the following criteria: eyes 8 on each side of the head; body with finely striated scales; lateral tooth on either side of the unguis, basal inner teeth not winglike; well developed tenent hair present; mesonotum projects over the reduced pronotum, obscuring it; ventral surface of the dentes with scales.

The problems involved in making generic and specific determinations of some members of the order Collembola concern finding reliable morphological key characters to separate them one from the other. The small size of Collembola forced early workers to restrict their observations to limited

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anatomical differences and color patterns. When Sir John Lubbock (1873) published his great monograph on the Apterygota, a more organized and exacting approach to the study of Collembola began. He observed and recorded, both in text and figures, minute structures ignored by earlier taxonomists. Detailed comparative systematic work on the order was initiated at the beginning of the 20th century with the work of Carl Börner (1901 and 1906) and until recently has not changed significantly in character.

The first advances in chaetotaxy began with Bonet (1945), who described the chaetotaxy of the head of some species of Hypogastrura. Delamare-Debouttville (1951) surveyed the known information on macrochaetae and trichobothria associated with soil-type Collembola and related these structures to phylogeny. Yosii (1956) described the basic chaetotaxy of the Hypogastruridae and distinguished each seta of the head and body segments. Cassagnau (1959) discussed the distribution of macrochaetae on the tergites of Tetracanthella. He stated that the position of the macrochaetae was of great systematic importance. Using chaetotaxic patterns he was able to divide Tetracanthella into three chaetotaxic types. In his revision of the genus Entomobrya, Christiansen (1958) used chaetotaxy to a limited extent. He divided the body setae into five types based on shape and lengths, but made no use of gross body setal patterns except on the male genital plate. Yosii (1959) revised the genus Seira and utilized the distribution of the macrochaetae on the tergites. Gisin (1960) used chaetotaxy of various groups to advantage in his discussion of species and included setal pattern drawings for his new species.

As Yosii has pointed out in an earlier paper (1956), the use of chaetotaxy is an important taxonomic tool. Yosii (1960) refined his work on Hypogastrura and attempted to define the evolution of the selected species he worked with and to show affinities. Once again using chaetotaxy, Yosii (1961) surveyed the Collembola, and related the family groups phylogenetically.

Gisin (1961) in reworking the collection of Carl Börner elaborated the species descriptions using chaetotaxy. Gisin and DaGama (1962) compared the chaetotaxy of three species of Seira. They found that the setae showed differences in relative distances from each other. As chaetotaxic technique developed, authors put it to use in difficult situations. Cassagnau (1964) made a comparative study of the dorsal chaetotaxy of Hypogastrura and was able to group closely allied species by pattern type. Massoud (1964) used a chaetotaxic table in describing a new species. Christiansen (1964) used position of the macrochaetae for specific identification. He also mentioned that the microsetae associated with the trichobothria are constant in position.

Murphy (1966) discussed the taxonomy and bionomics of Sphaeridia, utilizing the dorsal head and body chaetotaxy. He assigned a notation system to the setae which was followed in his descriptions of species. Betsch and Cassagnau (1966) described the evolution and form of the chaetotaxy of the abdominal papillae of Arrhopalites from the juvenile to the adult stage. Christiansen (1966), in a revision of Arrhopalites, systematically used chaetotaxy to characterize species.

The understanding of the chaetotaxy for the genus Lepidocyrtus has been largely due to the efforts of one man, Dr. Hermann Gisin. In a paper dealing with the Lepidocyrtini, Gisin (1963) discussed the pseudopores and chaetotaxy of this tribe, and illustrated the chaetotaxic pattern for Pseudosinella, a genus closely allied to Lepidocyrtus. In this paper he outlined a basic chaetotaxic map analogous to the setal maps used in describing lepidopterous larvae, and set down a notation system for the tribe Lepidocyrtini.

Gisin (1964a) presented a partial revision of the genus Lepidocyrtus s. str. in which he was able to show differences between species. This first article was concerned with seven species. Using only the mid-dorsal setae, he managed to develop four categorical chaetotaxic groups within the genus for European species: 1) Lepidocyrtus curvicollis Bourlet, Lepidocyrtus violaceous Geoffroy and Lepidocyrtus instratus Handschin; 2) Lepidocyrtus languginosus Gmelin and Lepidocyrtus cyaneus Tullberg; 3) Lepidocyrtus paradoxus Uzel; 4) Lepidocyrtus fimetarius Gisin.

Previously L. violaceous Geoffroy and L. cyaneus Tullberg had been difficult to separate. He noted that they could be distinguished with chaetotaxic characters. This discovery eventually led to other usable morphological differences in separating these two very similar species. Dr. Gisin showed that the dorsal chaetotaxy of abdominal segment IV differed between L. cyaneus and L. violaceous on the microchaetal level. Gisin (1964b) later developed more refined techniques for their separation. His studies of the genus Lepidocyrtus led to the use of the taxonomic characteristics of fine structures associated with the macrochaetae which had heretofore never been considered. Gisin was able to separate L. lignorum Fabricius from L. curvicollis Bourlet, a species that had up to this time masked lignorum on general morphological characters.

Gisin (1965) separated Lepidocyrtus pallidus Reuter from L. cyaneus Tullberg using chaetotaxy. At the same time he distinguished Lepidocyrtus serbicus Denis from L. pallidus Reuter and described a new species, Lepidocyrtus felxicollis Gisin, a species closely related to L. curvicollis.

Hale (1966) made use of the precepts laid down by Gisin and studied L. lignorum intensively, demonstrating that there is some variation in macrochaetal size between individuals of the same species.

Two of the species described as new in this paper were observed by Dr. Justus Watson Folsom in the late nineteen twenties. Dr. Folsom made preliminary observations of the species described herein, Lepidocyrtus millsi n. sp. and Lepidocyrtus floridensis n. sp., but never published his results. Through Dr. Harlow Mills the efforts of Dr. Folsom were made available. I have made use of Dr. Folsom's habitus drawings where applicable and have given him credit. Death prevented completion of work on the genus Lepidocyrtus by Dr. Folsom. It is to his credit that work 30 years old has stood the test of time and is still valid.

MATERIALS AND METHODS

The specimens used in this study were obtained, where possible, from the collections in the Entomology Museum, Michigan State University. This collection was augmented by specimens of Lepidocyrtus on loan from: the Illinois Natural History Survey; the United States National Museum; the University of Michigan Museum; the collection of Dr. Kenneth Christiansen of Grinnell College, Iowa; the collection of Dr. H. Goto, Imperial College, London, England; and the Museum of Natural History, Geneva, Switzerland through Dr. Hermann Gisin. Without the cooperation of these sources this study would not have been possible.

All specimens which have been examined were taken from alcohol-preserved collections, as previously made slide mounts were not usually of the nature which allowed good microscopic work. In my experience, 95%

ethanol is the best all around preservative. It tends to make the specimens stiff, but the color and integrity of the exoskeleton remain intact much better than in other preservative solutions which have been tried.

To make observations of the chaetotaxy in the genus Lepidocyrtus, it was necessary that specimens be placed on microscope slides. Specimens of all species described in this paper were prepared in the following manner:

1. The individuals were placed in 95% ethanol if not previously preserved in the same.
2. They were decapitated and the appendages removed, including the collophore. The head was placed aside for separate mounting as it is easily lost in a watch glass of alcohol.
3. With very fine pins mounted in match stick handles, a cut was made along the mid-ventral line from prothorax to anus. The specimen was held by the furcula while the cutting was done.
4. The preparation was then placed into a 5.25% solution of sodium hypochlorite. The clearing of the specimen must be closely observed since it proceeds very rapidly (3-5 minutes). Clearing in such a manner insures that all body contents are dissolved with nothing remaining except the exoskeleton.
5. The cleared exoskeleton was rinsed twice with distilled water (5 minutes each). This removes the sodium hypochlorite.
6. The specimen was then placed on a microscope slide dorsal side up in a drop of water, and the slide was tilted at an angle so the water drained from beneath the specimen. Excess water was removed with blotting paper.
7. A drop of CMC-10* was placed next to the wet preparation, allowed to penetrate the specimen, and a 12-mm. number zero, round coverslip was placed on the slide.
8. With the coverslip in place, generally heat from an alcohol lamp, would expand the exoskeleton and float folded edges into position.
9. After 48 hours the coverslip could be ringed with asphalt.

Specimens which were used for examination of the fine structures and trichobothria were mounted directly from 95% ethanol into CMC-10 and allowed to "cure" for at least a week. This process, although slow, retained the macrochaetae, trichobothria, and other fine structures in position. It is highly desirable to use this technique because it permits preparation of a large quantity of slides in a short time.

CHAETOTAXY

I. The Macrochaetal Pattern

The techniques referred to in the preceeding section permitted close examination of the dorsal and lateral macrochaetae. The basic positions of the dorsal macrochaetae and lasiotrichia described by Gisin (1964 and 1965) agree with the present observations. However, he did not include the lateral setae, and placed the species he examined into species groups. I

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*Available from Turtox, General Biological Supply House, Inc.

have attempted to follow his examples wherever possible, but have departed by showing a macrochaetal pattern for each species.

The constituents of the macrochaetal pattern include the macrochaetae, lasiotrichia, and pseudopores. The macrochaetae (fig. 1) are pubescent and arise from sockets surrounded by a chitinous ring. Lasiotrichia (Salmon, 1964) are long, fringed, sensory hairs (fig. 2) and are found on abdominal segments II, III, and IV. Pseudopores (Gisin and DaGama, 1962) are structures which resemble pseudocelli, but lack internal structure (fig. 3). Gisin and DaGama (1962) described a thin thread arising externally from the center of the pseudopore. I have not as yet observed such a structure. The pseudopores occur on each body segment and Gisin (1963) reports that they also occur on the coxae. Figure 4 is a composite chaetotaxal pattern and is representative of all possible macrochaetae. A black dot indicates a macrochaeta, an open circle (o) represents a pseudopore, and a short, curved line represents a lasiotrichium.

The species treated are arranged in order of their pattern complexity, beginning with the most complex. Three basic regions of the trunk are noted: the medial region (M), the paramedial (P), and the lateral region (L) (fig. 4). These regions agree with the natural groupings of the macrochaetae which are constant throughout the genus. All designated setae are indicated by a segment number, region letter, and position subscript number. For example, the first medial seta on abdominal segment IV is referred to as: ABD IV, M_1. Lasiotrichia are designated by a "t" and a subscript number such as: ABD IV, Mt_2. By following this system, one is able to indicate the presence or absence of a given seta by a notation. Setae below the lateral edge of the body are not indicated, as they are beyond the scope of the present study, as are also the setae of the parafurcular lobes and the setae of abdominal segments V and VI.

Abdominal segment IV is the most variable in number and position of setae. On the basis of macrochaetae, two distinct groups of species may be discerned; group "A", with 3 medial macrochaetae; group "B", with two medial macrochaetae. If the species are arranged under A and B groups (table 1), they may be listed numerically from greater to lesser numbers of macrochaetae.

TABLE 1.--Groups of species for North American Lepidocyrtus based on the numbers of medial macrochaetae of ABD IV

"A" Group	"B" Group
L. lignorum	L. cinereus
unifasciatus	lanuginosus
finensis	heleni
curvicollis	millsi
neofasciatus	floridensis
paradoxus	pallidus
violaceous	cyaneus

Tables 2 and 3 summarize the macrochaetal pattern of the 14 species examined. Thoracic segments II and III, and abdominal segment I have only pseudopores, otherwise completely lack chaetotaxic elements, and

are therefore omitted from tabulations. It is significant to note that M_1 is always present on ABD II and always lacking on ABD III; likewise, the paramedials (P) are always lacking on both of these segments. Lateral seta (L_1) is consistently present on ABD II, but all other laterals are lacking on that particular segment. All 14 species have the same pattern of lasiotrichia which is as follows: ABD II, Mt_1, L_1; ABD III, Mt_1, Lt_1t_2; ABD IV, Pt_1t_2 (fig. 4). Any unique positions or deletions are discussed under the individual species.

TABLE 2.--Lateral macrochaetotaxal formulae of abdominal segment III of Lepidocyrtus

Species	
L. lignorum	$L_1\ L_2\ L_3$
unifasciatus	$L_1\ L_2\ L_3\ L_4$
finensis	$L_1\ L_2\ L_3$
curvicollis	$L_1\ L_2\ L_3$
neofasciatus	$L_1\ L_2\ L_3$
paradoxus	$L_1\ L_2\ L_3$
violaceous	$L_1\ L_2\ L_3$
cinereus	$L_1\ L_2\ L_3$
lanuginosus	$L_1\ L_2\ L_3$
heleni	$L_1\ L_2\ L_3$
millsi	$L_1\ L_2\ L_3$
floridensis	$L_1\ L_2$
pallidus	$L_1\ L_2\ L_3$
cyaneus	$L_1\ L_2$

II. The Accessory Microchaetae Associated with the Lateral Lasiotrichia of Abdomen III

Two lateral lasiotrichia and two macrochaetae (ABD III, $t_1t_2L_1L_2$) are located on abdominal segment III. Associated with these structures are microchaetae composing patterns which are species specific. I have adopted a simple lettering system to designate the individual setae.

Lasiotrichium t_1 has a maximum of four pubescent microchaetae, commonly arranged in a crescent shape, anterior in position to it. They are referred to as $a_1a_2a_3a_4$. Commonly a_2 drops out of the pattern. Posterior to lasiotrichium t_1 two additional microchaetae, b_1b_2, are found.

Similarly lasiotrichium t_2 has four microchaetae, $c_1c_2c_3c_4$, arranged in a horizontal line drawn through the two lasiotrichia.

TABLE 3.--Macrochaetotaxal formulae of abdominal segment IV of *Lepidocyrtus*

Species			
L. lignorum	$M_1M_2M_3$	P_1 P_3 P_5P_6	$L_1L_2L_3L_4L_5L_6$ L_8 $L_{10}L_{11}L_{12}L_{13}L_{14}L_{15}L_{16}L_{17}$
unifasciatus	$M_1M_2M_3$	P_1 P_5	L_1L_2 L_4 L_6L_7 $L_9L_{10}L_{11}L_{12}L_{13}L_{14}L_{15}L_{16}L_{17}L_{18}$
finensis	$M_1M_2M_3$	P_1 P_3 P_5	$L_1L_2L_3L_4$ L_6 L_8 $L_{10}L_{11}$ $L_{13}L_{14}$ $L_{16}L_{17}L_{18}$
curvicollis	$M_1M_2M_3$	P_1 P_3	$L_1L_2L_3L_4$ $L_6L_7L_8$ $L_{10}L_{11}$ $L_{14}L_{15}L_{16}L_{17}$ L_{19}
neofasciatus	$M_1M_2M_3$	P_1 P_3 P_5	$L_1L_2L_3L_4$ L_6 L_8 $L_{10}L_{11}$ L_{14} $L_{16}L_{17}$
paradoxus	$M_1M_2M_3$	P_1 P_5	$L_1L_2L_3L_4$ $L_8L_9L_{10}L_{11}$ $L_{13}L_{14}$ L_{16} L_{18}
violaceous	$M_1M_2M_3$	P_1 P_3 P_5	$L_2L_3L_4$ L_6 L_8 $L_{10}L_{11}$ $L_{14}L_{15}L_{16}L_{17}$
cinereus	M_2M_3	P_1P_2 P_4	L_2 L_4 $L_6L_7L_8$ L_{10} $L_{12}L_{13}L_{14}L_{15}L_{16}L_{17}L_{18}$
lanuginosus	M_2M_3	P_1 P_4P_5	$L_2L_3L_4$ L_6 $L_{10}L_{11}L_{12}$ $L_{14}L_{15}L_{16}L_{17}$
heleni	M_2M_3	P_1 P_4	$L_1L_2L_3$ L_6 L_9 L_{12} L_{14} $L_{16}L_{17}L_{18}L_{19}$
millsi	M_2M_3	P_1 P_3 P_5	$L_2L_3L_4$ L_6 L_8 L_{14} $L_{16}L_{17}$ L_{19}
floridensis	M_2M_3	P_4P_5	$L_2L_3L_4L_5$ L_8 L_{10} $L_{13}L_{14}L_{15}$ L_{18}
pallidus	M_2M_3	P_1 P_4	$L_1L_2L_3L_4$ $L_{10}L_{11}L_{12}L_{13}L_{14}$ L_{16}
cyaneus	M_2M_3	P_1 P_4	$L_1L_2L_3L_4$ L_6 L_{12} L_{14} L_{16}

No microchaetae are known to be directly associated with macrochaeta L_1. However, two smooth microchaetae, one long (d_1), and the other short (d_2), are positioned mesad of macrochaeta L_2.

Four possible microchaetae, lateral of the $t_1 t_2 L_1 L_2$ pattern, are referred to as $e_1 e_2 e_3 e_4$, in an anterior to posterior position. Occasionally there are supplementary microchaetae associated with t_1 which are designated as s_1 and s_2. See figures 19-32 for positions and relative sizes of microchaetae. Table 4 indicates the comparison of the fourteen species examined.

III. The Accessory Microchaetae Associated with the Anterior Lasiotrichia of Abdomen IV

Gisin (1964) described and named the microchaetae associated with the anterior lasiotrichia of the fourth abdominal segment (ABD IV, $P_1 t_1$) (figs. 33-36). He comments that the triangular pattern formed by these microchaetae is not of particular significance. And the patterns for species overlap in many instances, allowing only grouping of species under the resultant patterns. Gisin's system of notation is as follows: "One may distinguish one external hair (e), one anterior (a) and one medial (m). In the center of the triangle formed by the three hairs, one supplementary hair (s) is developed ....," one (mp) medial posterior is present. This notation system for the accessories has been followed.

CHAETOTAXY OF NORTH AMERICAN SPECIES

Lepidocyrtus lignorum (Fabricius), 1775 sensu Gisin, 1964

Figures 5, 19, 33

Lepidocyrtus lignorum (Fabricius) is easily confused with Lepidocyrtus curvicollis Bourlet. North American taxonomists have designated, with few exceptions, L. lignorum as L. curvicollis. Dr. Gisin (in litt.) informed me that he thought L. lignorum was a common species compared to L. curvicollis. After rechecking the determined collections of the Illinois Natural History Survey and Michigan State University, it was apparent that this was indeed true. If color pattern alone is used to distinguish the species, it is impossible to reliably separate the two. Lepidocyrtus lignorum is far more common than L. curvicollis in North America.

CHAETOTAXY.--Lepidocyrtus lignorum has 29 setae on ABD IV (fig. 5), the largest number of setae of the species examined. It is unique, being the only species to have P_6 represented. The laterals are very similar to L. unifasciatus from L_6 to L_{17} (table 3).

The accessories of ABD III are simple plumose microsetae (fig. 19). Microseta d_1 is longer than d_2. This is a unique situation--the reverse is true in all other species. Supplementary (s_1) is very close to the first lasiotrichia (t_1). Table 4 indicates the microchaetal formula.

The accessories of ABD IV consist of e, a, m, mp (fig. 33), the most common pattern for the genus.

TABLE 4.--Table of comparative formulae for accessory microchaetae of ABD III of Lepidocyrtus

Species						
L. lignorum	a_1 a_3 a_4	b_1 b_2	c_2	d_1 d_2	e_3 e_4	s_1
unifasciatus	a_1 a_2 a_3 a_4	b_1 b_2	c_2	d_1 d_2		
finensis	a_1 a_2 a_3 a_4	b_1 b_2	c_3	d_1 d_2		
curvicollis	a_1 a_2	b_2	c_1 c_3			s_1
neofasciatus	a_1 a_2 a_3 a_4	b_1 b_2	c_2		e_2 e_3	
paradoxus	a_1 a_3 a_4	b_1 b_2	c_2	d_1	e_3	s_2
violaceous	a_1 a_2 a_3 a_4	b_1 b_2	c_2	d_1 d_2		
cinereus	a_1 a_2 a_3 a_4		c_1 c_2 c_3 c_4	d_1 d_2		s_1
lanuginosus	a_1 a_3	b_1		d_1 d_2	e_2	s_1
heleni	a_1 a_2 a_3 a_4		c_2		e_1 e_2	s_1
millsi	a_1 a_2 a_3 a_4	b_2	c_1 c_2 c_3	d_1 d_2		
floridensis	a_1 a_2 a_3 a_4	b_1 b_2	c_2 c_3	d_2	e_1 e_2 e_3 e_4	
pallidus	a_1 a_3 a_4	b_1 b_2	c_2			
cyaneus	a_1 a_2 a_3 a_4	b_1 b_2				s_1

Lepidocyrtus unifasciatus James, 1933

Figures 6, 20, 33

This species is indigenous to North America. It can be distinguished from other members of the genus on the basis of a deep blue band on abdominal segment IV.

CHAETOTAXY. --L. unifasciatus has a macrochaetal pattern similar to that of L. lignorum (fig. 6). A striking difference is on ABD III with the addition of $\overline{L}_4$, which is the only instance where that macrochaeta was observed. Likewise, L. unifasciatus lacks ABD IV, P_3P_6, which are found on L. lignorum (table 3).

The accessories of ABD III (fig. 20) have the e series completely lacking, whereas in L. lignorum e_1 and e_2 are present (table 4).

The accessories of ABD IV (fig. 33) are of the usual pattern, e, a, m, mp.

Lepidocyrtus finensis Maynard, 1951

Figures 7, 21, 33

Lepidocyrtus finensis was observed by Folsom in the 1920's, but never described by him. Maynard collected the species in New York and published his findings (1951). Records of L. finensis are very rare, suggesting that it is an uncommon species. The specimens examined were collected in 1930 by C. A. Frost.

CHAETOTAXY. --L. finensis is close to L. curvicollis (table 3), according to the macrochaetae. However, it has ABD IV, $\overline{P}_5$ (fig. 7) which L. curvicollis lacks.

The accessories of ABD III are similar to those in L. unifasciatus (table 4), having c_3 instead of c_2 (fig. 21).

The accessories of ABD IV are of the e, a, m, mp type (fig. 33).

Lepidocyrtus curvicollis Bourlet, 1839 sensu Gisin, 1964

Figures 8, 22, 35

As previously mentioned, L. curvicollis is considered to be close to L. lignorum. Gisin (1964) could separate L. curvicollis once he discerned the species, by the presence of pigment on thoracic segment II. The species is not common in North America and previous determinations will have to be checked before its range can be recorded accurately.

CHAETOTAXY. --The dissimilarity to L. lignorum, based on macrochaetae, is apparent at once (table 3). Lepidocyrtus curvicollis lacks ABD IV P_5P_6 and $L_5L_{12}L_{13}$ (fig. 8), but has L_7L_{19} which is lacking on L. lignorum.

The accessories of ABD III have a simple pattern not found on L. lignorum (table 4). Microsetae a_2a_3 are absent, as well as d_1d_2. The supplementary seta (s_1) is present (fig. 22). The microsetae are strongly subclavate and pubescent.

The accessories of ABD IV are unique in arrangement (fig. 35) and the supplementary seta (s) is present.

Lepidocyrtus neofasciatus Wray, 1948, new status

Figures 9, 23, 33

When Wray (1948) described L. unifasciatus var. neofasciatus, he mentioned that there was some doubt concerning its systematic placement. James, who authored L. unifasciatus, checked the specimens and confirmed them as L. unifasciatus var. Chaetotaxic studies have revealed that neofasciatus is a valid species differing markedly from L. unifasciatus, and should stand alone.

CHAETOTAXY. --L. neofasciatus lacks the macrochaeta ABD III L_4 found on unifasciatus (table 3). It also has ABD IV P_3, which is not present on unifasciatus, and the L series of ABD IV is more disjunct (fig. 9).

The accessories of ABD III lack $d_1 d_2$, but have e_2 and e_3 (table 4) which are lacking on unifasciatus (fig. 23).

The accessories of ABD IV are of the e, a, m, mp type (fig. 33).

Lepidocyrtus paradoxus Uzel, 1890

Figures 10, 24, 34

L. paradoxus Uzel is one of North America's larger Collembola. Snider and Fischer (1964) recorded its presence in North America for the first time. European specimens for comparison were made available by Gisin, and a rediscription from Michigan specimens was made. Goto (1953) described L. christianseni as new, but Snider and Fischer's work has revealed it to be a synonym of L. paradoxus.

CHAETOTAXY. --The macrochaetal pattern is similar to those of L. neofasciatus, finensis and lignorum (table 3). The distribution of the L series on ABD IV is disjunct (fig. 10).

The accessories of ABD III are similar to those of L. lignorum with exception of ABD IV d_2, $e_1 e_2$ being absent on L. paradoxus. Both have supplementary setae, s_2 for paradoxus and s_1 for lignorum (table 4). The microchaetae are slightly clavate (fig. 24).

The accessories of ABD IV (fig. 34) have the supplementary seta (s) present.

Lepidocyrtus violaceous (Geoffroy), 1762
sensu Lubbock, 1873

Figures 11, 25, 33

There has been much discrepancy as to what constitutes the species Lepidocyrtus violaceous (Geoffroy) and Lepidocyrtus cyaneus Tullberg. For years taxonomists have confused the two species. Gisin (1964a) separated them by using chaetotaxy and then substantiated his findings with more obvious characters. The presence of scales on the first two segments of the antennae and legs in violaceous permits its separation from cyaneus. This character helped Gisin (1964b) to separate L. cyaneus var. assimilis Reuter from cyaneus and to place it in synonomy under L. violaceous.

CHAETOTAXY. --ABD III, L_3 is missing on L. cyaneus, but is present on L. violaceous (table 3). ABD IV, M_1 is present on L. violaceous, but

missing on L. cyaneus. The L series of ABD IV is the simplest of the A-group (table 1), having 3 medial macrochaetae on that segment (fig. 11).

The accessories of ABD III (table 4) are the same as L. unifasciatus. This is the only instance in the 14 species so far examined that repeats a pattern (fig. 25).

The accessories of ABD IV are of the e, a, m, mp type pattern (fig. 33).

Lepidocyrtus cinereus Folsom, 1924, new status

Figures 12, 26, 33

Folsom (1924) found minor differences between his new variety, cinereus, and L. cyaneus Tullberg s. str., but considered them insignificant. He commented on the color difference: cinereus is metallic grey, while cyaneus is deep blue. Notwithstanding he relegated cinereus to variety position. Gisin (1964a) identified cyaneus, but did not mention the cinereus variety, and later he was able to resurrect several valid species which had been placed in synonomy with cyaneus. Based on the chaetotaxy and the differences pointed out by Folsom, Lepidocyrtus cinereus Folsom is also a species distinct from cyaneus.

CHAETOTAXY. --The macrochaetae of ABD IV are the most complex of the B-group (table 1). Lepidocyrtus cinereus also has ABD IV, P_2 (table 3) which the others in the B-group are wanting (fig. 12).

The accessories of ABD III (table 4) lack the b and e series of microchaetae (fig. 26).

The accessories of ABD IV are of the e, a, m, mp type pattern (fig. 33).

Lepidocyrtus lanuginosus (Gmelin), 1788

Figures 13, 27, 36

Lepidocyrtus lanuginosus (Gmelin) could be confused with lignorum in size and color. Indeed, it is my belief that Maynard (1951) had the two confused. Gisin (1964a) separated them on the presence or absence of scales on the antennal segments I and II and legs. L. lanuginosus lacks those scales, lignorum does not.

This species is not common in the collections from North America examined by me.

CHAETOTAXY. --The macrochaetae pattern is somewhat similar to L. floridensis n. sp. (table 3). Thoracic segment II has a lateral seta (L_1). ABD IV, $P_1P_4P_5$ is an unusual combination in the B-group species (fig. 13).

The accessories of ABD III are reduced in number (table 4, fig. 27).

The accessories of ABD IV are of the e, a, m, mp type. However, e is longer than normal, as in L. cyaneus (fig. 36).

Lepidocyrtus helenae, new species

Figures 14, 28, 33, 37-43

Body length up to 1 mm. The basic body color is violet, arranged on the body segments and appendages as follows: antennal segment I dark violet, segment II for the basal three quarters light violet merging on almost white

at base, the apical quarter forms a dark ring, segment III violet, segment IV violet; the precoxae and coxae violet, trochanter light violet, remainder of leg white; furcula white; head dorsally with diffuse violet pigment becoming darker in the genal area and very dark in the post-genal area, an anterior black band connects the eye patches, ventrally the head is violet to light violet; mesothorax up to and including abdominal segment II with dark violet fascia, abdominal segment III sometimes with a small patch of lateral violet, segment IV with a irregular violet fascia interrupted in the mid-dorsal region; parafurcular lobes dusted with small amounts of violet pigment (figs. 37 & 39); eyes 8 + 8 on dark patches (fig. 42); mouth parts prognathous with a well developed molar plate on the mandible; antennal segments in the ratio of 2: 6: 4: 8 (fig. 43); mesothorax enlarged, but not projecting into a cone; ungues lanceolate with three inner teeth, unguiculus lanceolate with 4-5 small teeth on its outer margin (fig. 41); a well-developed clavate tenant hair is present; corpus of the tenaculum with one large irregular seta, rami with four teeth (fig. 38); manubriun to dentes ratio 4: 5, dentes with many dorsal crenulations; mucro typical of the genus with one apical tooth and anteapical tooth with an anteapical spine pointed toward it from the basal position (fig. 40); scales on the head, trunk, and ventrally on the manubrium, lacking on the legs from the trochanter to the claw and also not present on the antennae --the usually fringed setae mixed with normal curving setae on the body.

CHAETOTAXY. --The macrochaetae are disjunct in the L series of ABD IV (table 3, fig. 14).

The accessories of ABD III lack the b series and d series (table 4; fig. 28).

The accessories of ABD IV are of the e, a, m, mp type (fig. 33).

TYPES. --Holotype, Michigan, Monroe County, T75 R6E S24, June 17, 1965, collected by R. J. Snider. Paratypes, 8 individuals taken on the same date as the holotype. Additional paratypes: Monroe Co., T75 R6E S24, June 23, 1965, 2 specimens; June 29, 4 specimens; July 5, 2 specimens; July 11, 1 specimen; July 17, 3 specimens; July 23, 38 specimens; August 4, 3 specimens; August 16, 5 specimens; August 22, 3 specimens; September 9, 2 specimens; all of which were collected by R. J. Snider in pit trap samples. The holotype and paratypes are deposited in the Michigan State University collection.

This species is commonly taken in small numbers with other members of the genus in pit-trap samples. It is usually found in the litter of hardwood forest floors where L. paradoxus, violaceous, unifasciatus and cyaneus occur. I have collected L. helenae from June through September in Michigan. While it does not constitute a large part of the collembolan population in the woodlots of southern Michigan, it is frequent in most samples collected.

It is my pleasure to name this species after Mrs. Helen M. Snider who for so many years put up with the "bug hunting" peculiarities of her son.

Lepidocyrtus millsi, new species

Figures 15, 29, 33, 44-50

Body length up to 1 mm. The basic body color is dark blue, arranged on the segments and appendages as follows: antennal segment I light blue, segment II pale basally with blue pigment on the distal quarter forming a ring, segment III pale blue becoming dark blue on the distal quarter forming

a dark ring, segment IV pale blue becoming somewhat darker on the apical half; precoxae and coxae blue, remainder of leg white; furcula uniformly white; head dorsally dusted with light blue in some individuals, in others white, an anterior dark band connects the eye patches and has an enlarged medial spot, ventral side of the head may have some light blue dusting; trunk segments from the second thoracic up to and including abdominal segment III always have dark blue fasciae, abdominal segment IV with a dark blue fascia at the midpoint of the segment, the parafurcular lobes sometimes dusted with light blue (figs. 44, 46); eyes 8 + 8 on dark patches (fig. 49); mouthparts prognathous with well developed molar plate on the mandible; antennal segments in the ratio of 2: 4: 3: 7 (fig. 50); mesothorax enlarged, but not projecting anteriorly into a cone; ungues lanceolate with two inner teeth, unguicula simple and lanceolate, a single weakly developed tenent hair is present (fig. 48); corpus of the tenaculum with one large irreguiar seta, rami with four teeth (fig. 45); manubrium to dentes ratio 4: 4.5, dentes with many dorsal crenulations; mucro typical of the genus with one anteapical tooth and apical tooth with a spine pointing toward the anteapical tooth from its basal position; scales occurring on the greater part of the trunk, head, and ventrally on the furcula, scales lacking on the antennal segments and on the legs from the trochanter to the claw. The macrochaetae are fringed and quite long, interspersed with short curving normal setae.

CHAETOTAXY.--The macrochaetae are simple in their pattern arrangement (fig. 15). There is a gap between ABD IV, L_8 and L_{14}. This is the only species in the B-group to have the ABD IV, $P_1P_3P_5$ pattern (table 3).

The accessories of ABD III are more complex in arrangement than the other species of the B-group (table 4). Also, d_1d_2 are almost of the same size (fig. 29).

The accessories of ABD IV fit into the e, a, m, mp type pattern (fig. 33).

TYPES.--Holotype, Putnam County, Springdale, March 19, 1927, collected by T. H. Hubbell. Paratypes, 20 individuals taken on the same date as the holotype. The holotype and paratypes are deposited in the Illinois Natural History Survey collection. Five paratype specimens are in the Michigan State University collection.

This species could easily be confused with Lepidocyrtus helenae but may be separated by the nature of the claws. L. helenae has three inner teeth on the unguis, while millsi has two. Also, helenae has a serrated outer margin on the unguiculus which makes it unique.

I take pleasure in naming this species after Dr. Harlow B. Mills, who has been so helpful during the beginning years of my efforts in Collembola taxonomy.

Lepidocyrtus floridensis, new species

Figures 16, 30, 34, 51-57

Length of body up to 1 mm. The basic body color is white with dark blue-black maculations laid down in flecks of pigment distributed as follows: antennal segment I light blue throughout, segments II and III light blue becoming darker apically, segment IV uniformally light blue; legs entirely white except coxae frequently with a light dusting of dark blue which continues over basal fourth of the trochanter; furcula white; ventral side of the head with a light dusting of dark-blue black pigment, the dorsal side with a

dark anterior band connecting the eye patches; mesotergum and metatergum with a dark blue-black lateral macula; the first segment of abdomen with blue-black fascia interrupted mid-dorsally with white, sometimes continuous; abdominal segment IV with a blue-black fascia, frequently discontinuous to the extent that only a patch may be seen laterally on either side of the segment (figs. 51, 52); eyes 8 and 8 on dark patches (fig. 55); mouthparts prognathous, with a well-developed molar plate on the mandible; antennal segments in the size ratio of 2: 3: 3: 6 (fig. 54); mesothorax enlarged, but not projecting anteriorly into a cone; ungues lanceolate with an outer basal tooth and three inner teeth, unguicula with four outer teeth and lanceolate, a single clavate tenent hair (fig. 56); corpus of the tenaculum with one large irregular seta, rami with four teeth (fig. 53); manubrium and dentes in the ratio of 1: 1, with many dorsal crenulations on the dentes; mucro with large apical tooth and a basal spine pointing toward anteapical tooth (fig. 57); scales on the greater part of the body and on the ventral surface of the furcula, scales not occurring on the legs from the trochanter to the claw, or on the first two segments of the antennae. The basic setae of the body are fringed and are heavy on the legs.

CHAETOTAXY.--The macrochaetae of ABD IV lacks P_1 which is found on all other species described in this paper (table 3). The L series show a disjunct pattern (fig. 16).

The accessories of ABD III (table 4) are very numerous, only the supplementaries are missing. The microchaetae are subclavate (fig. 30). The seta d_1 is missing.

The accessories of ABD IV resemble L. paradoxus (fig. 34).

TYPES.--Holotype, Florida, Stock Island, December 29, 1951, collected by R. Richards and L. Stannard. Paratypes, 108 individuals collected on the same date as the holotype. Additional paratypes were collected from the following Florida localities: Sanibel Island, April 26, 1927, M. D. Leonard, collector, 16 specimens; Everglades National Park, Royal Palm Ranger Station, December 27, 1951, Richards and Stannard, collectors, 21 specimens; Key West, December 27, 1951, Richards and Standard, collectors, 5 specimens. The habitat for this species is grass clumps and ground litter.

Holotype and paratypes are deposited in the Illinois Natural History Survey collection. 20 paratypes are also in the Michigan State University collection.

Lepidocyrtus pallidus (Reuter), 1890 sensu Gisin, 1965

Figures 17, 31

Lepidocyrtus pallidus (Reuter), originally considered a valid species, has commonly been placed into the cyaneus complex as a variety. Gisin (1965), using chaetotaxy and morphological characters, resurrected the species. His dorsal chaetotaxy drawing of the body associate it with L. lanuginosus and cyaneus. The species has been further defined in this study.

CHAETOTAXY.--The macrochaetal pattern is similar to L. cyaneus, but differs on ABD IV lacking L_6L_{13} and by having in addition $L_{10}L_{11}$. (table 3; fig. 17).

The accessories of ABD III lack the d and e series (table 4) and supplementaries (fig. 31).

The accessories of ABD IV are of the e, a, m, mp type pattern (fig. 33).

Lepidocyrtus cyaneus Tullberg, 1871

Figures 18, 32, 36

Having been confused with L. violaceous for so many years, L. cyaneus was often misidentified in North America until Gisin (1964) redefined cyaneus. I believe that cyaneus is not as common as violaceous in our fauna. The presence of scales on antennal segments I, II and the legs separate cyaneus from violaceous.

CHAETOTAXY. --Thoracic segment II bears a lateral macroseta (L_1) (fig. 18). ABD III L_3 is missing. The macrochaetae of ABD IV are the least numerous of all 14 species considered here (tables 2 and 3).

The accessories of ABD III lack the c, d, and e series as well as supplementaries (table 4). The microchaetae are subclavate and small (fig. 32).

The external accessory (e) of ABD IV is almost twice the normal length (fig. 36), similar to L. lanuginosus.

SUMMARY

The mounting technique described in this work proved useful in making microscopic examinations of 14 species of Lepidocyrtus s. str. found in North America.

The macrochaetal patterns of the species were studied and illustrated. Two major groups of species were discerned within the genus on the basis of macrochaetae. Microchaetae (accessories) were described from abdominal segments III and IV. The combination of macro- and microchaetal patterns characterize the species studied and give foundation to the definition of individual species. Chaetotaxy is not considered as an end in itself, but rather, an aid for the identification of difficult species.

Chaetotaxy was used in identification of three new species; Lepidocyrtus helenae, Lepidocyrtus millsi, and Lepidocyrtus floridensis. Specific status for two varieties was proposed; Lepidocyrtus neofasciatus Wray and Lepidocyrtus cinereus Folsom.

It is hoped that future work of a revisionary nature on the group will be made easier and be given a more uniform method of presenting chaetotaxic data as a result of this study.

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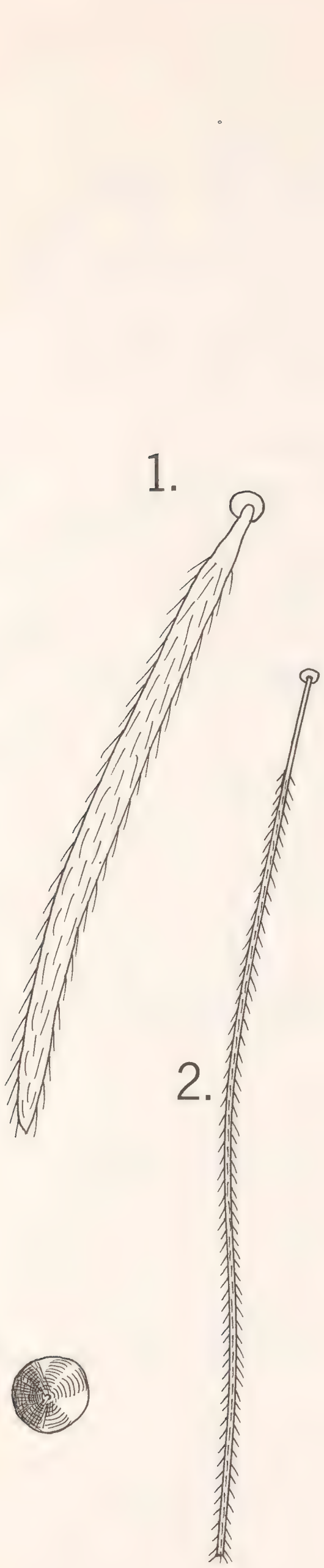


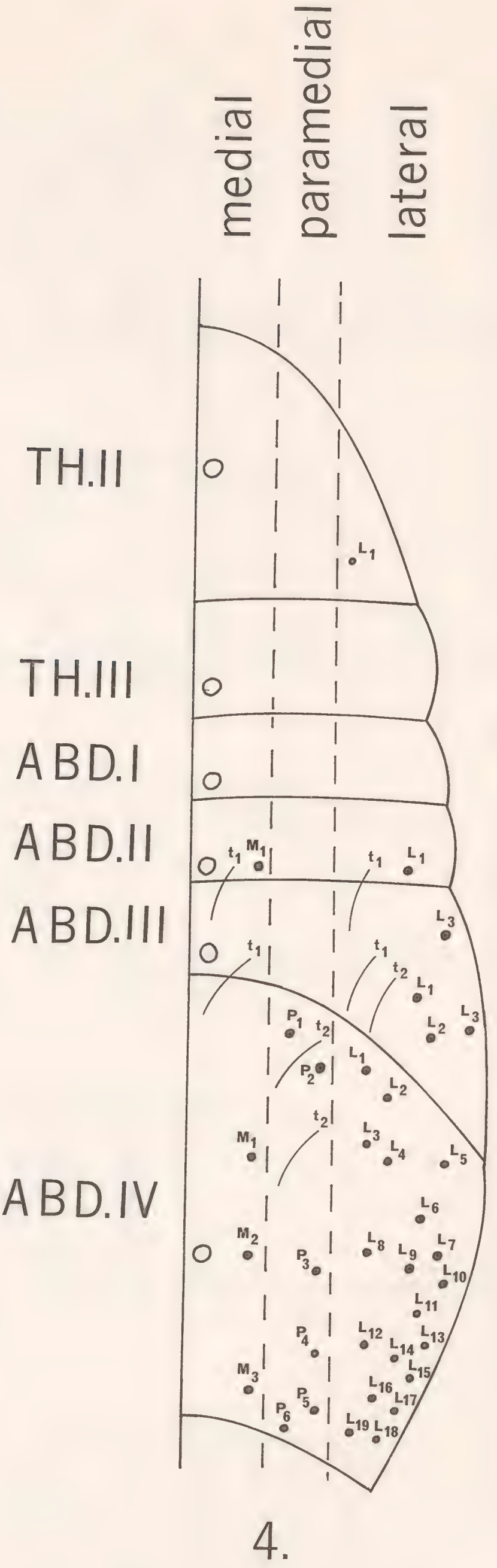


Fig. 1.--Macrochaeta. Fig. 2.--Lasiotrichium. Fig. 3.--Pseudopore. Fig. 4.--Dorsal composite view of Lepidocyrtus indicating the regions of the body and positions of the macrochaetal elements.

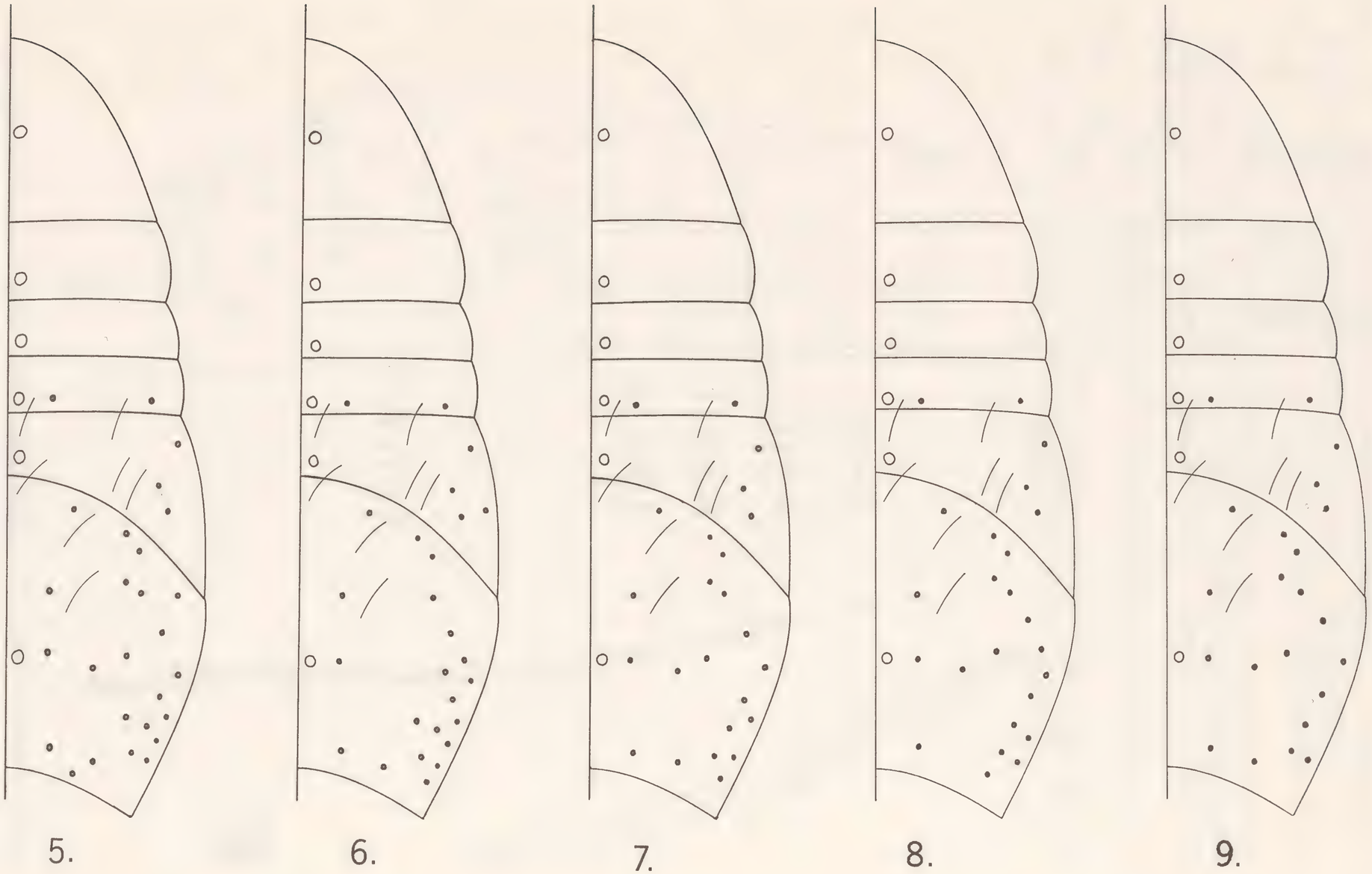


Fig. 5.--Lepidocyrtus lignorum (Fabricius), dorsal macrochaetae. Fig. 6.--Lepidocyrtus unifasciatus James, dorsal macrochaetae. Fig. 7.--Lepidocyrtus finensis Maynard, dorsal macrochaetae. Fig. 8.--Lepidocyrtus curvicollis Bourlet, dorsal macrochaetae. Fig. 9.--Lepidocyrtus neofasciatus Wray, n.c., dorsal macrochaetae.

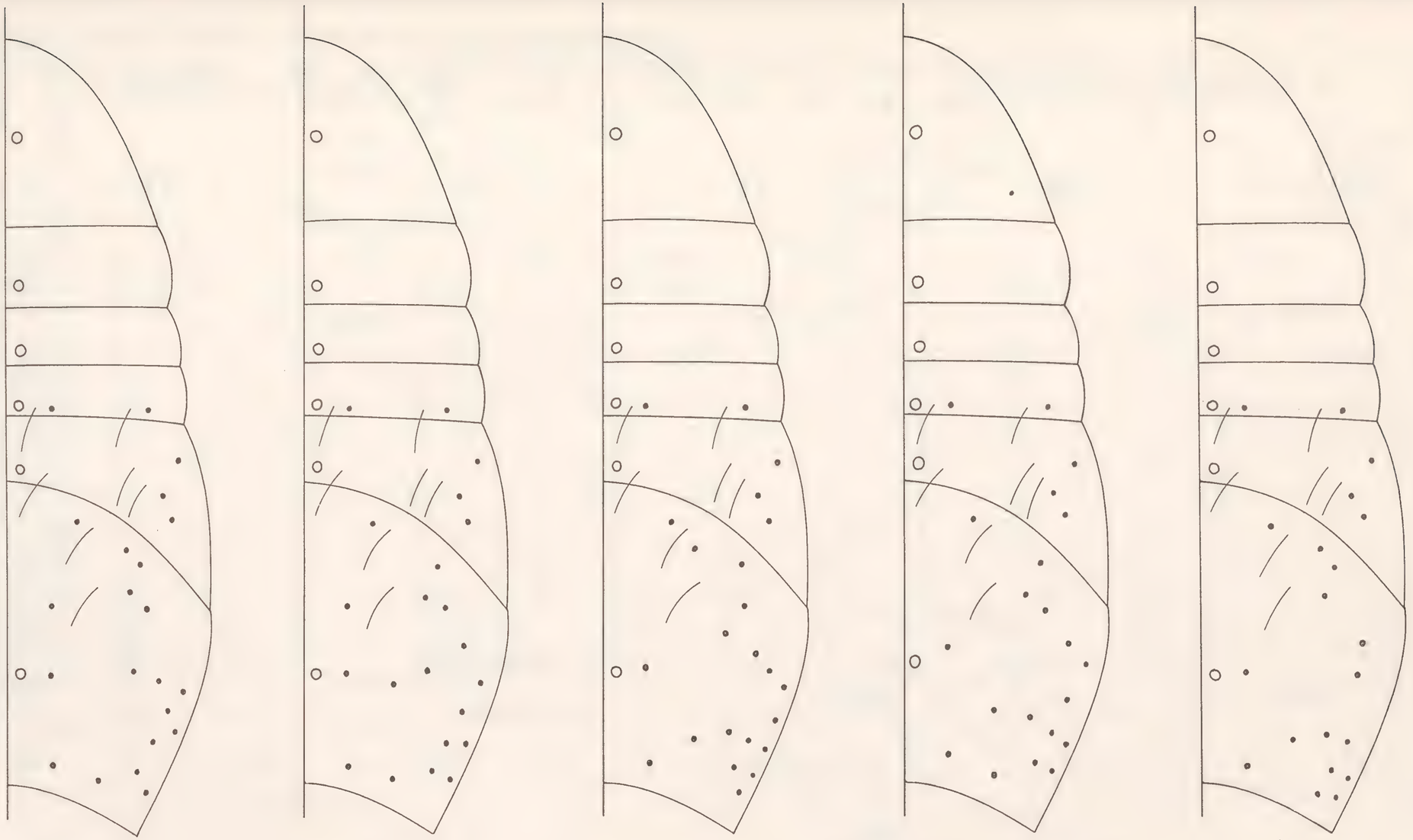
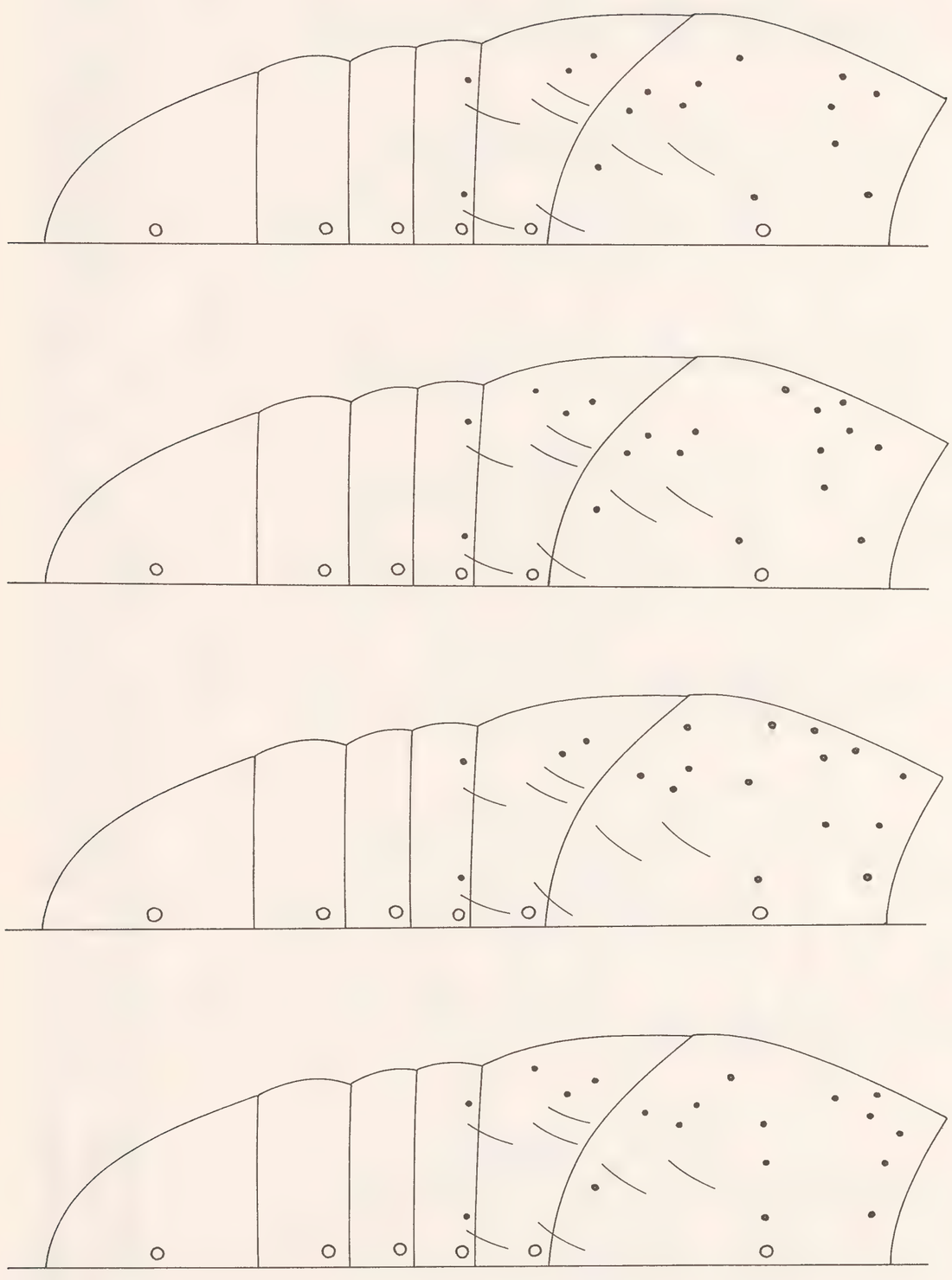


Fig. 10.--Lepidocyrtus paradoxus Uzel, dorsal macrochaetae. Fig. 11.--Lepidocyrtus violaceous (Geoffroy), dorsal macrochaetae. Fig. 12.--Lepidocyrtus cinereus Folsom, n.c., dorsal macrochaetae. Fig. 13.--Lepidocyrtus lanuginosus (Gmelin), dorsal macrochaetae. Fig. 14.--Lepidocyrtus helenae n. sp., dorsal macrochaetae.



15. 16. 17. 18.

Fig. 15.--Lepidocyrtus millsi n. sp., dorsal macrochaetae. Fig. 16.--Lepidocyrtus floridensis n. sp., dorsal macrochaetae. Fig. 17.--Lepidocyrtus pallidus (Reuter), dorsal macrochaetae. Fig. 18.--Lepidocyrtus cyaneus Tullberg, dorsal macrochaetae.

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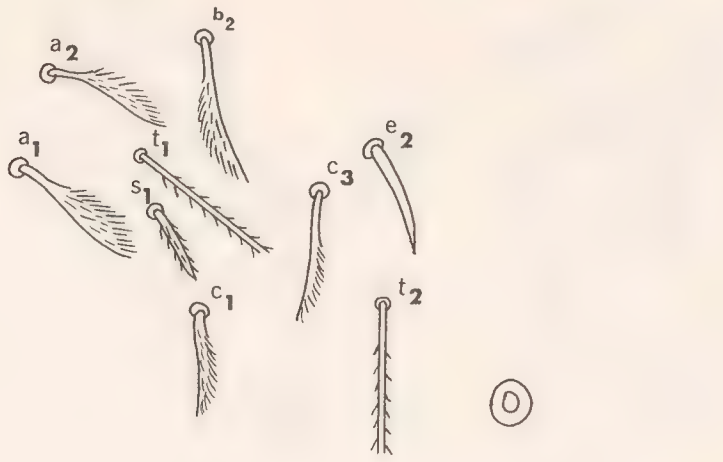

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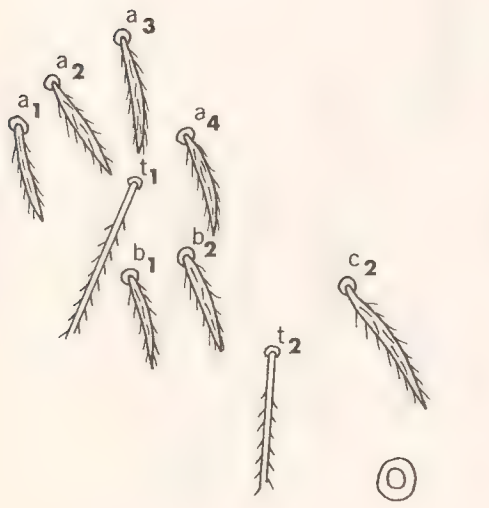

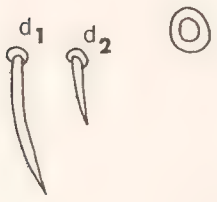

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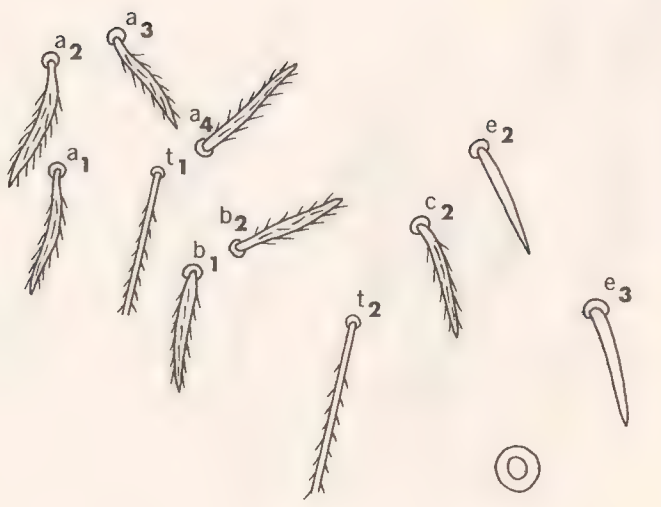

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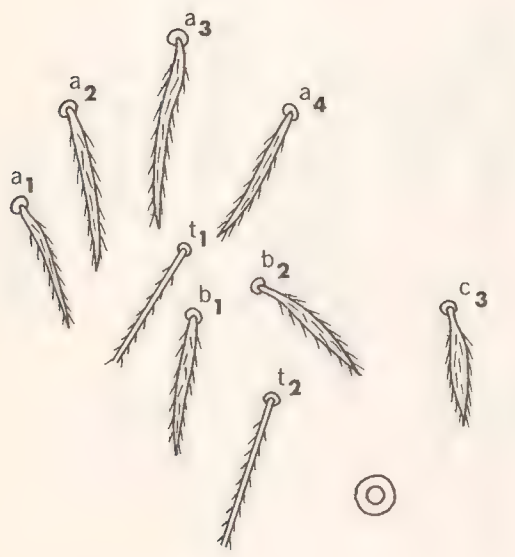

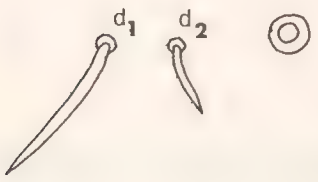

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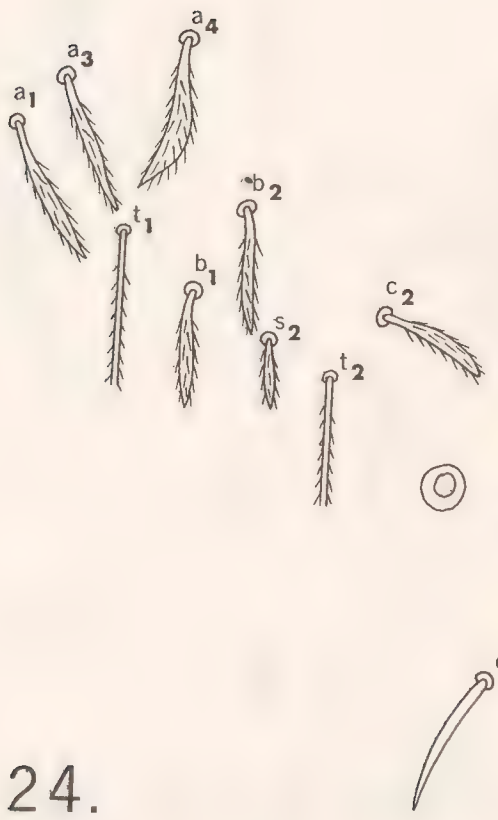

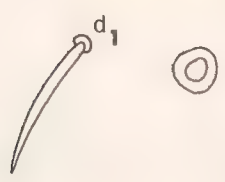

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The Microchaetae (Accessories) of ABD III. Fig. 19.--L. lignorum. Fig. 20.--L. unifasciatus. Fig. 21.--L. finensis. Fig. 22.--L. curvicollis. Fig. 23.--L. neofasciatus. Fig. 24.--L. paradoxus.

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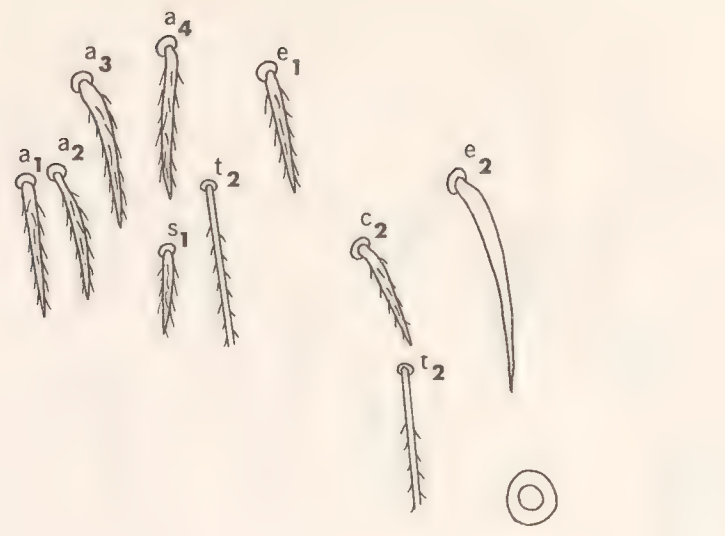

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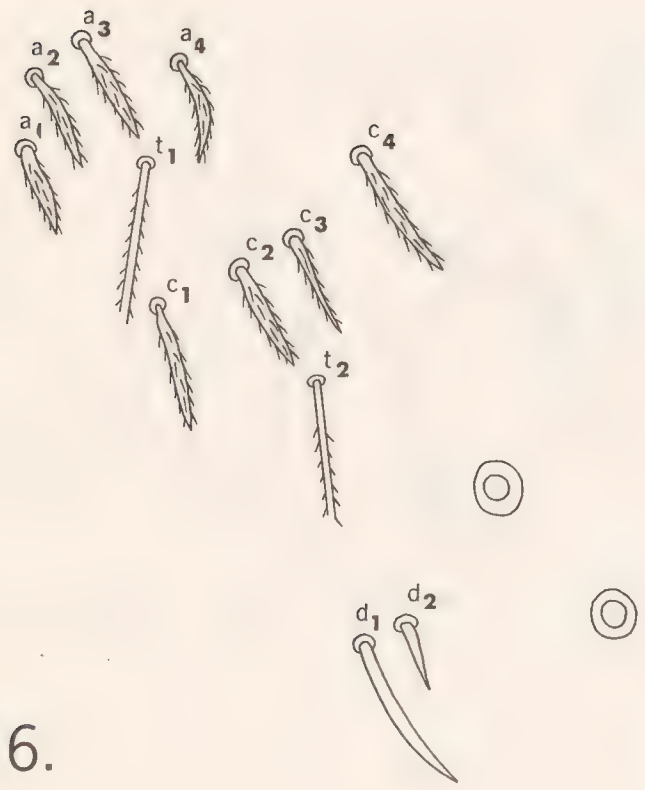

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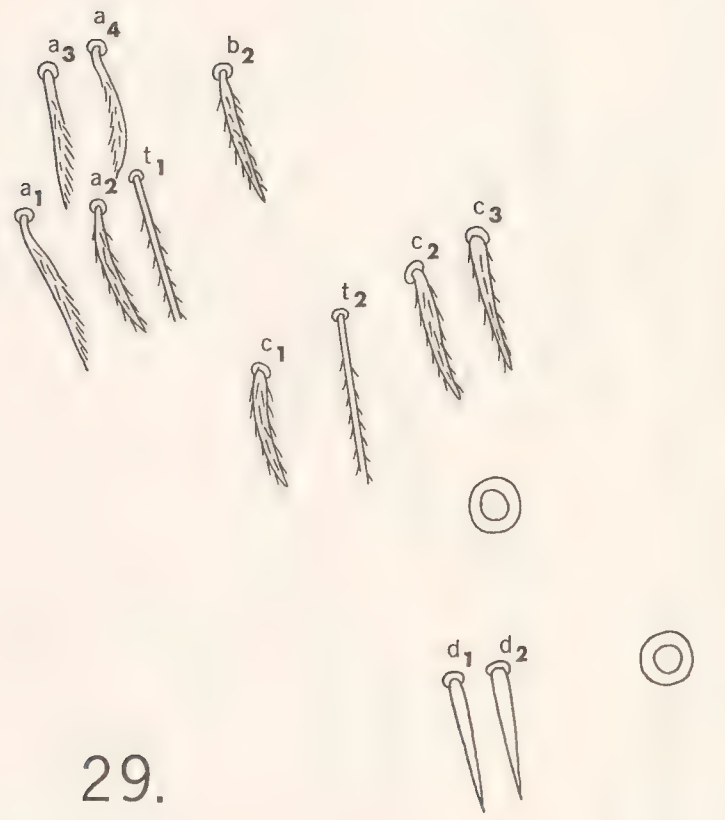

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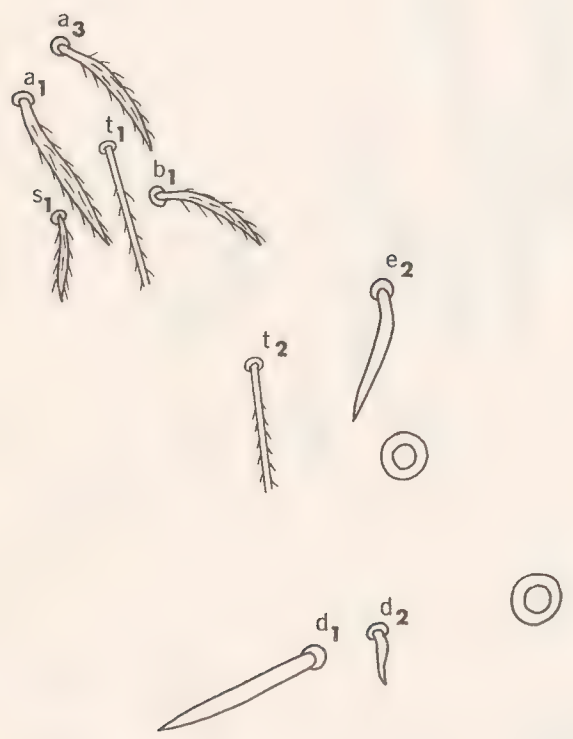

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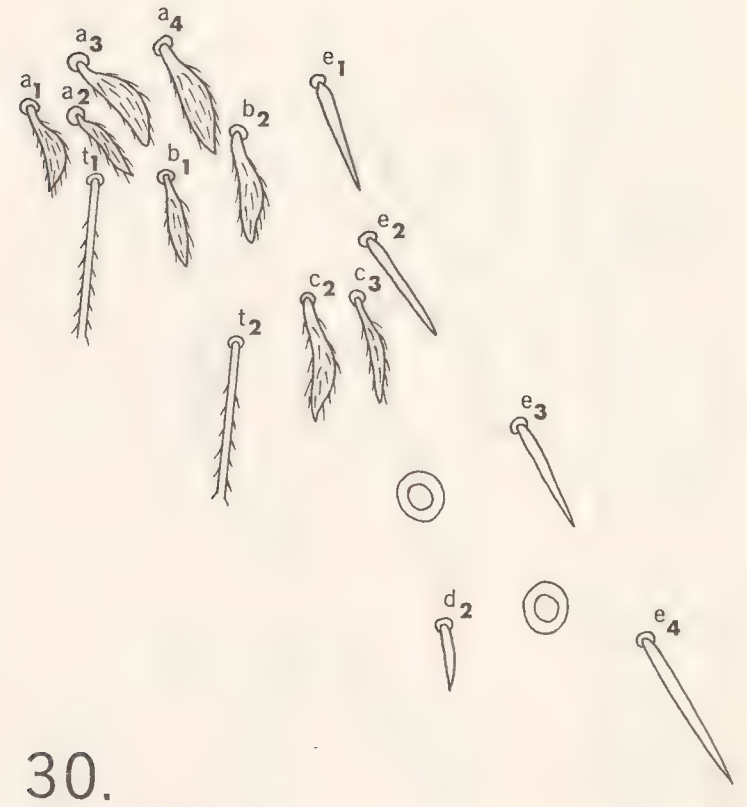
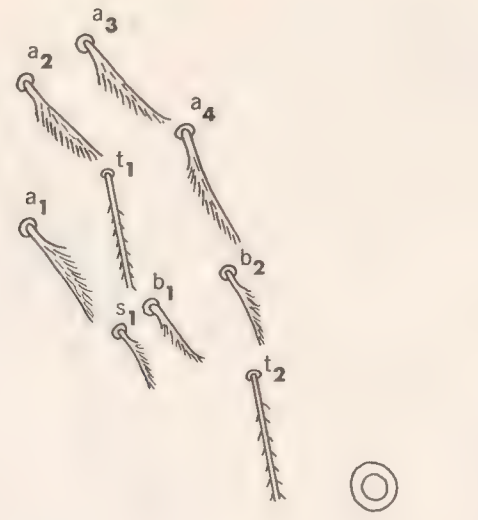


30.

The Microchaetae (Accessories) of ABD III. Fig. 25.--L. violaceous. Fig. 26.--L. cinereus. Fig. 27.--L. lanuginosus. Fig. 28.--L. helenae. Fig. 29.--L. millsi. Fig. 30.--L. floridensis.

31.



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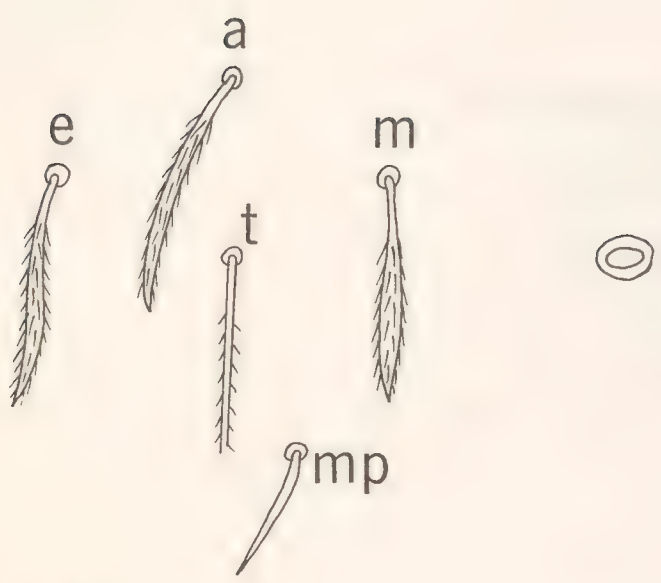

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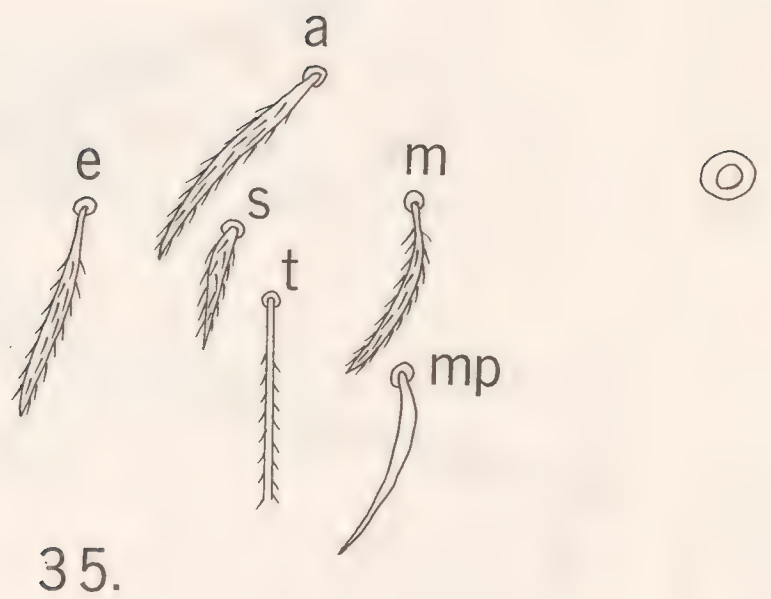

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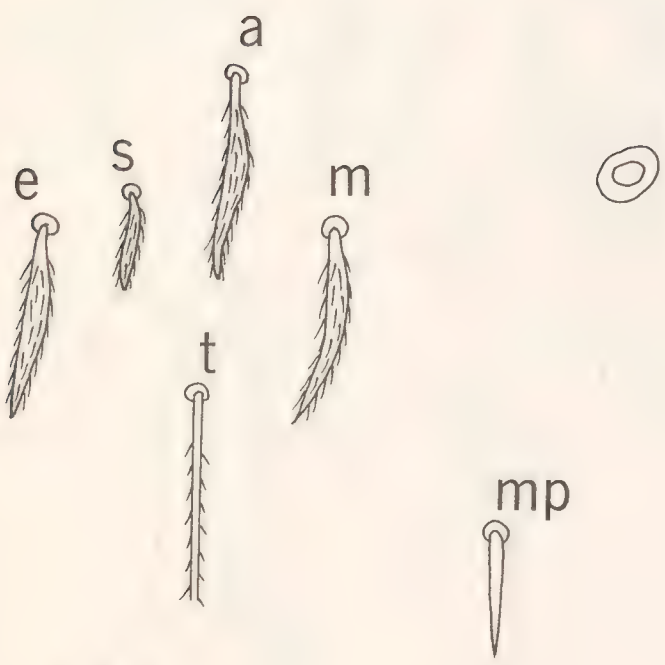

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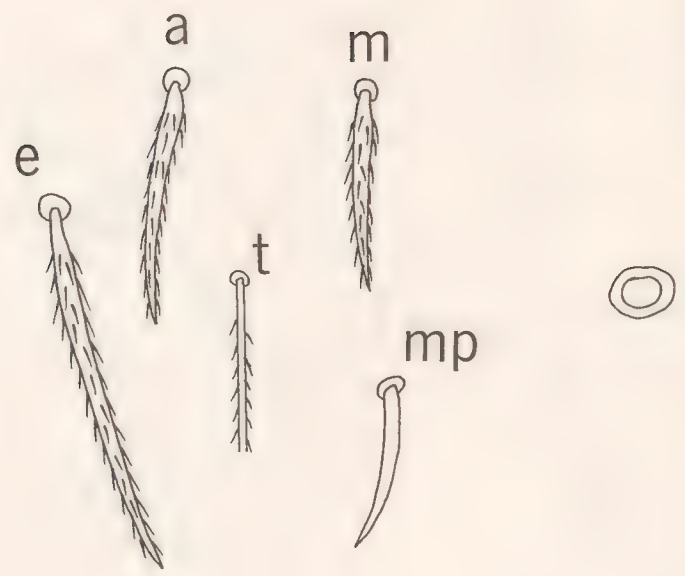
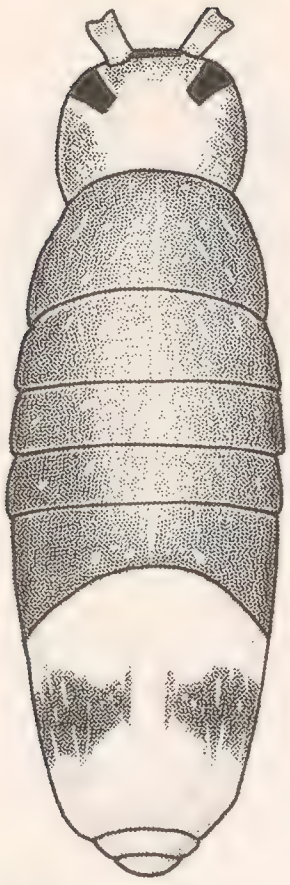


36.

The Microchaetae (Accessories) of ABD III. Fig. 31.--L. pallidus. Fig. 32.--L. cyaneus. The Microchaetae (Accessories) of ABD IV. Fig. 33.--L. lignorum, unifasciatus, finensis, neofasciatus, violaceous, cinereus, helenae, millsi. Fig. 34.--L. paradoxus, floridensis. Fig. 35.--L. curvicollis. Fig. 36.--L. lanuginosus, cyaneus.



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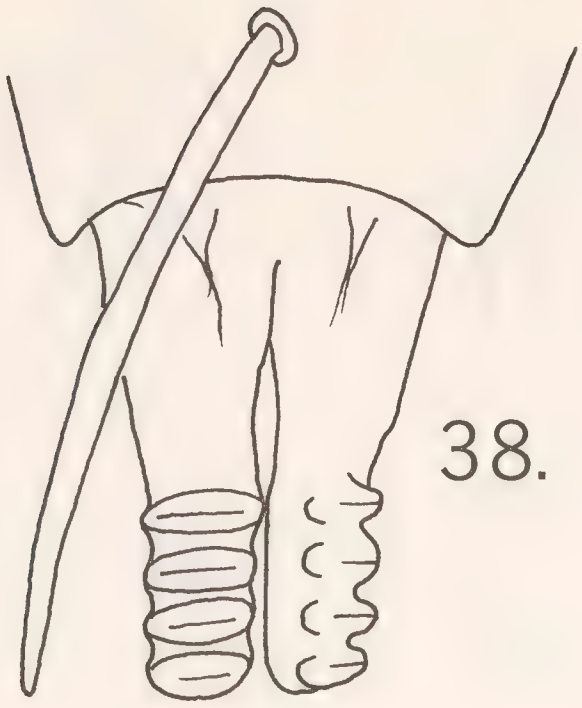

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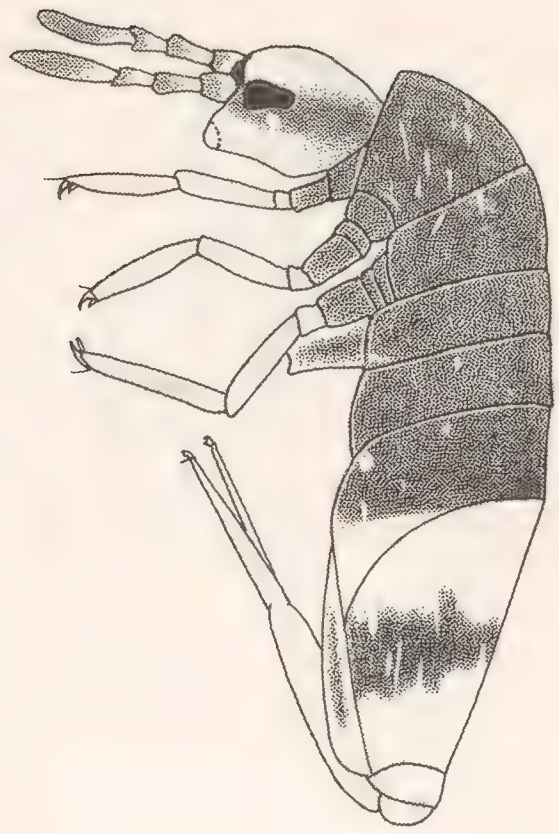
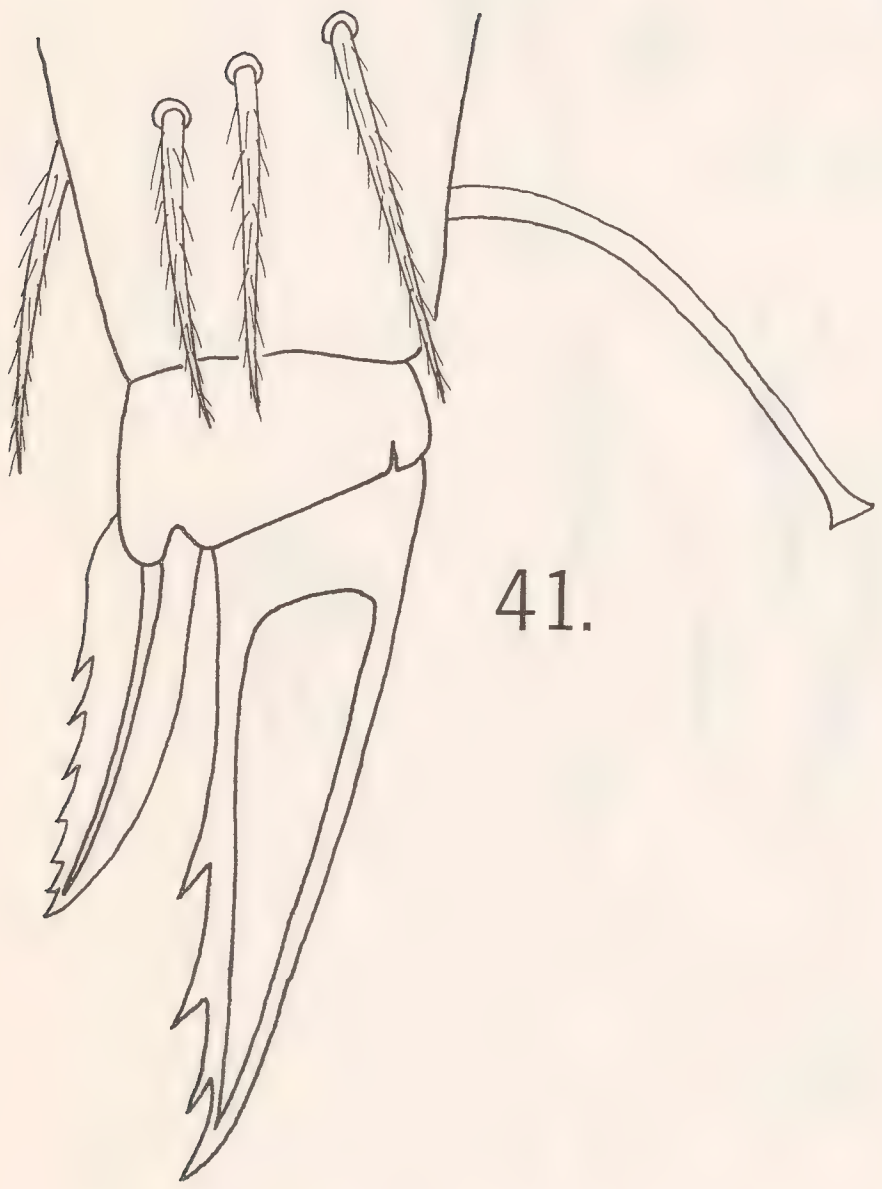


39.

40.



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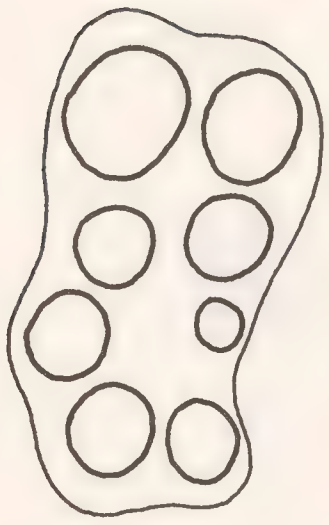
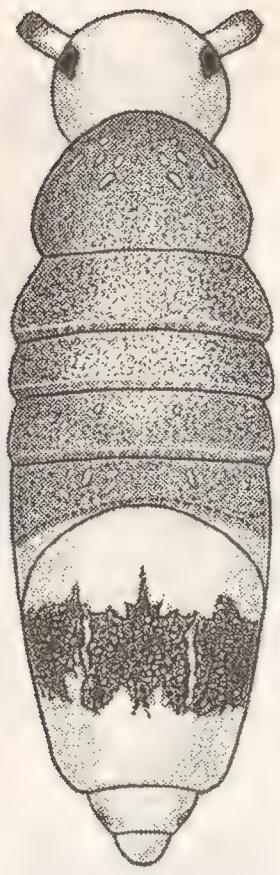


42.

43.

Snider

Lepidocyrtus helenae n. sp. Fig. 37.--L. helenae, dorsal view habit drawing. Fig. 38.--Tenaculum with seta. Fig. 39.--L. helenae, lateral view habit drawing. Fig. 40.--Mucro. Fig. 41.--Right claw of third leg. Fig. 42.--Eye patch of left side of head. Fig. 43.--Antenna.



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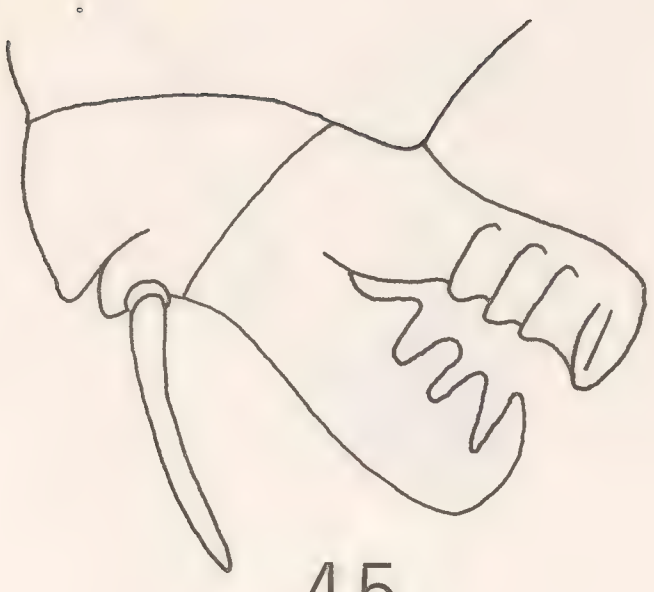

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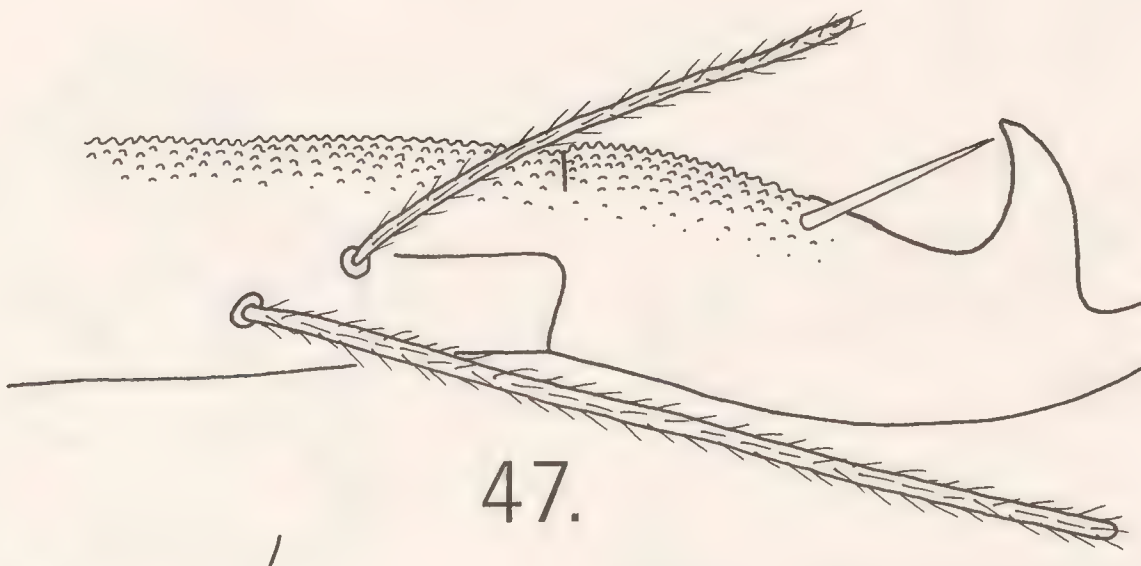
46.



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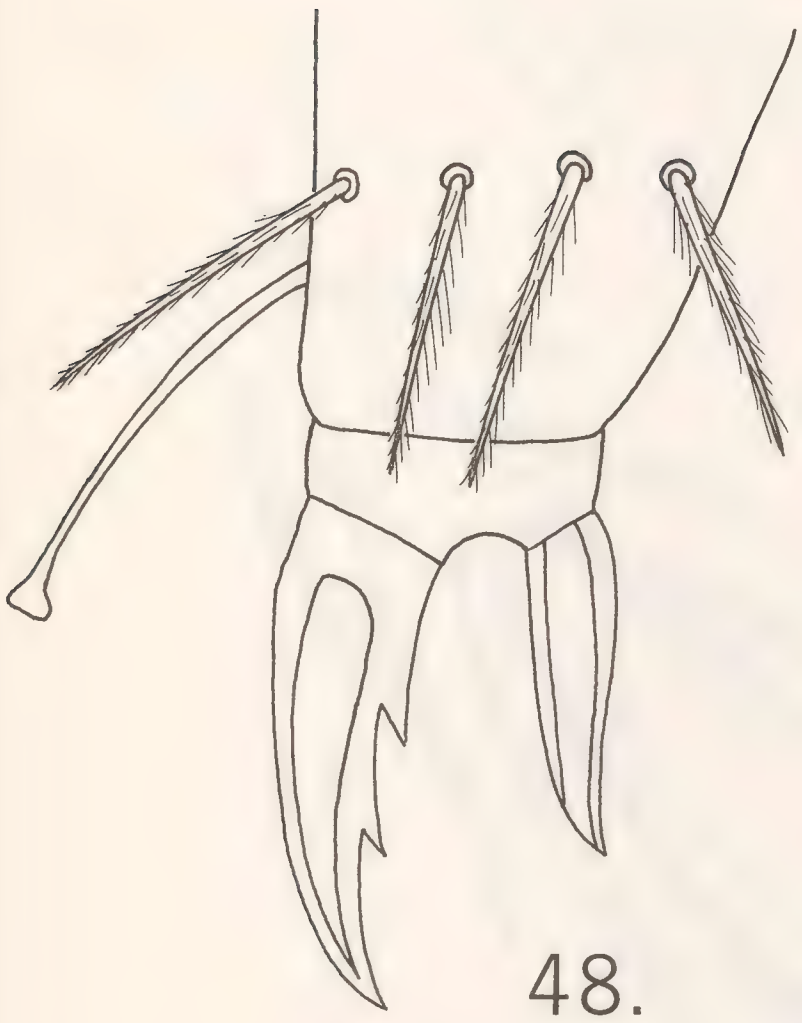

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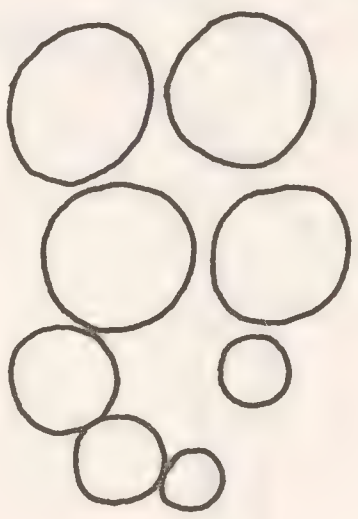

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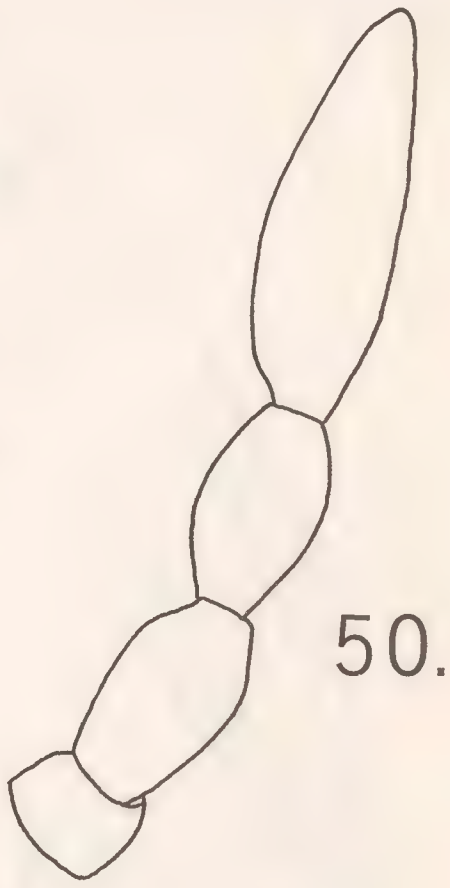
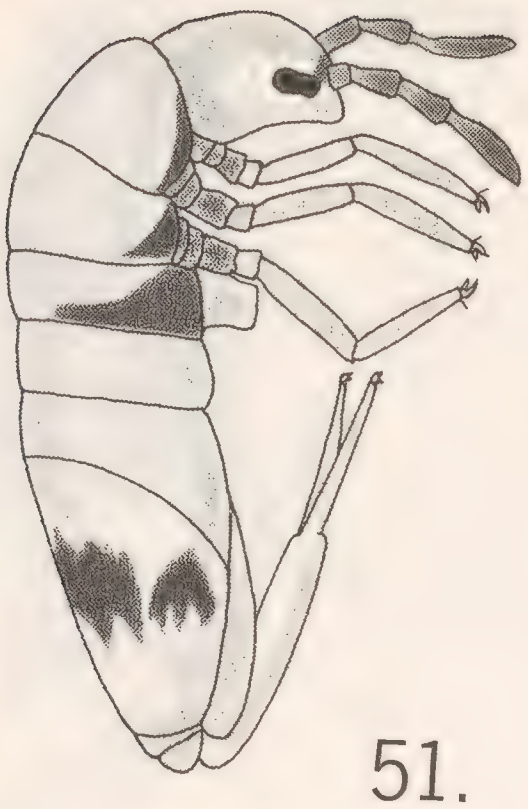


50.

Snider

Lepidocyrtus millsi n. sp. Fig. 44.--L. millsi, dorsal view habit drawing (drawing by J. W. Folsom). Fig. 45.--Tenaculum with seta. Fig. 46.--L. millsi, lateral view habit drawing. Fig. 47.--Mucro (after Folsom). Fig. 48.--Right claw of third leg (after Folsom). Fig. 49.--Eye patch of left side of head (after Folsom). Fig. 50.--Antenna.



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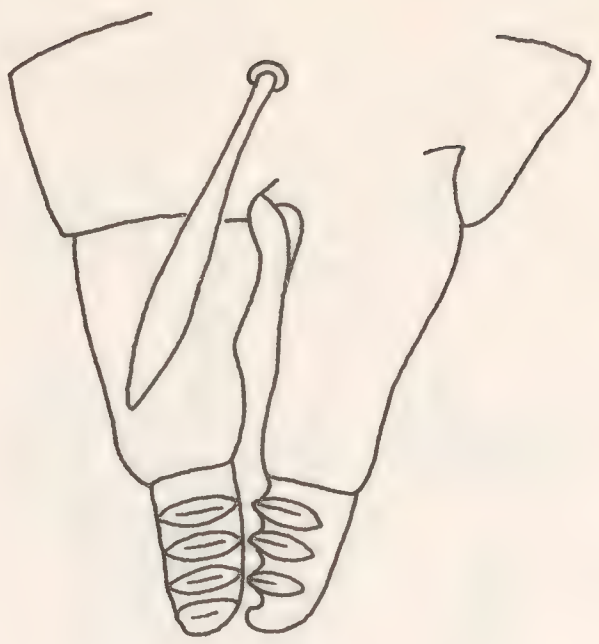

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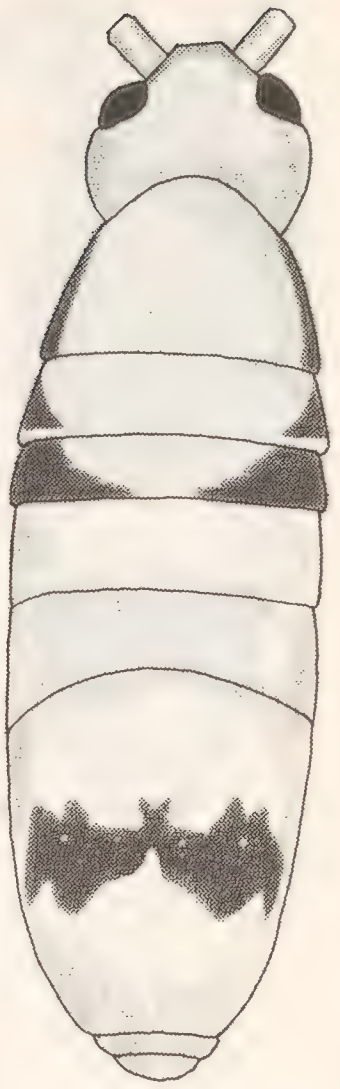

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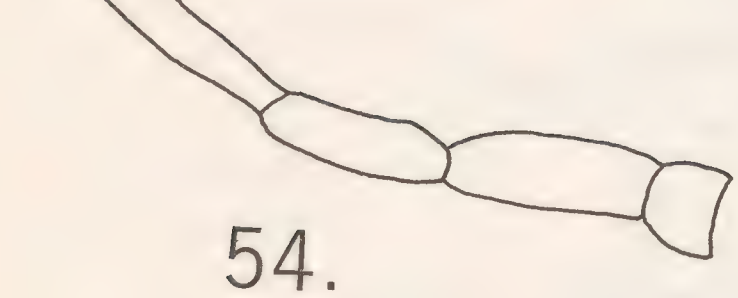

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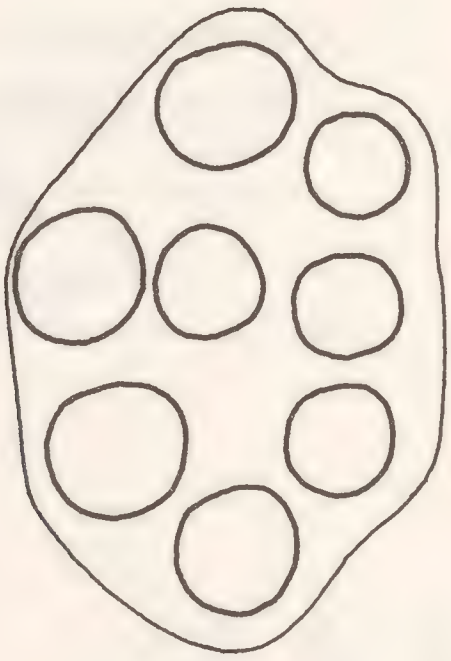

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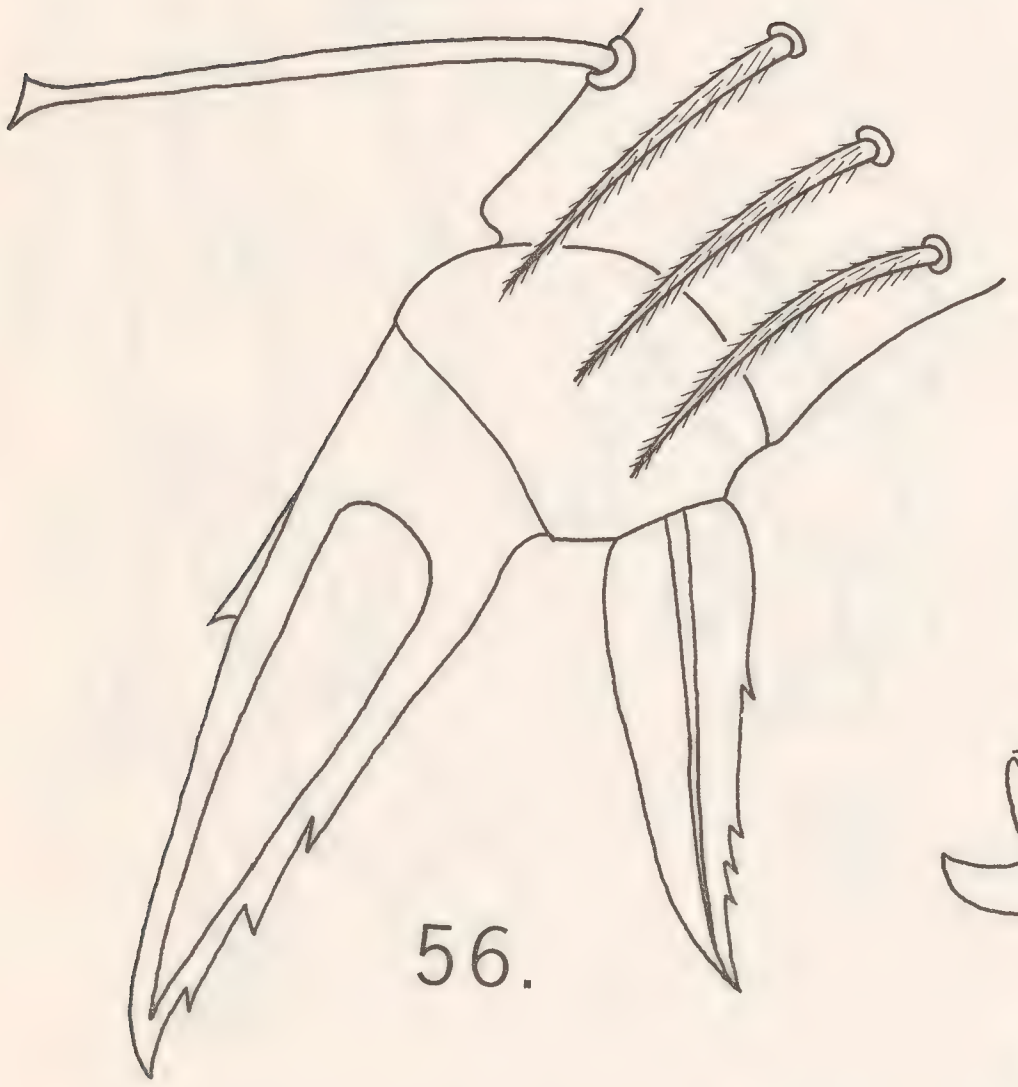

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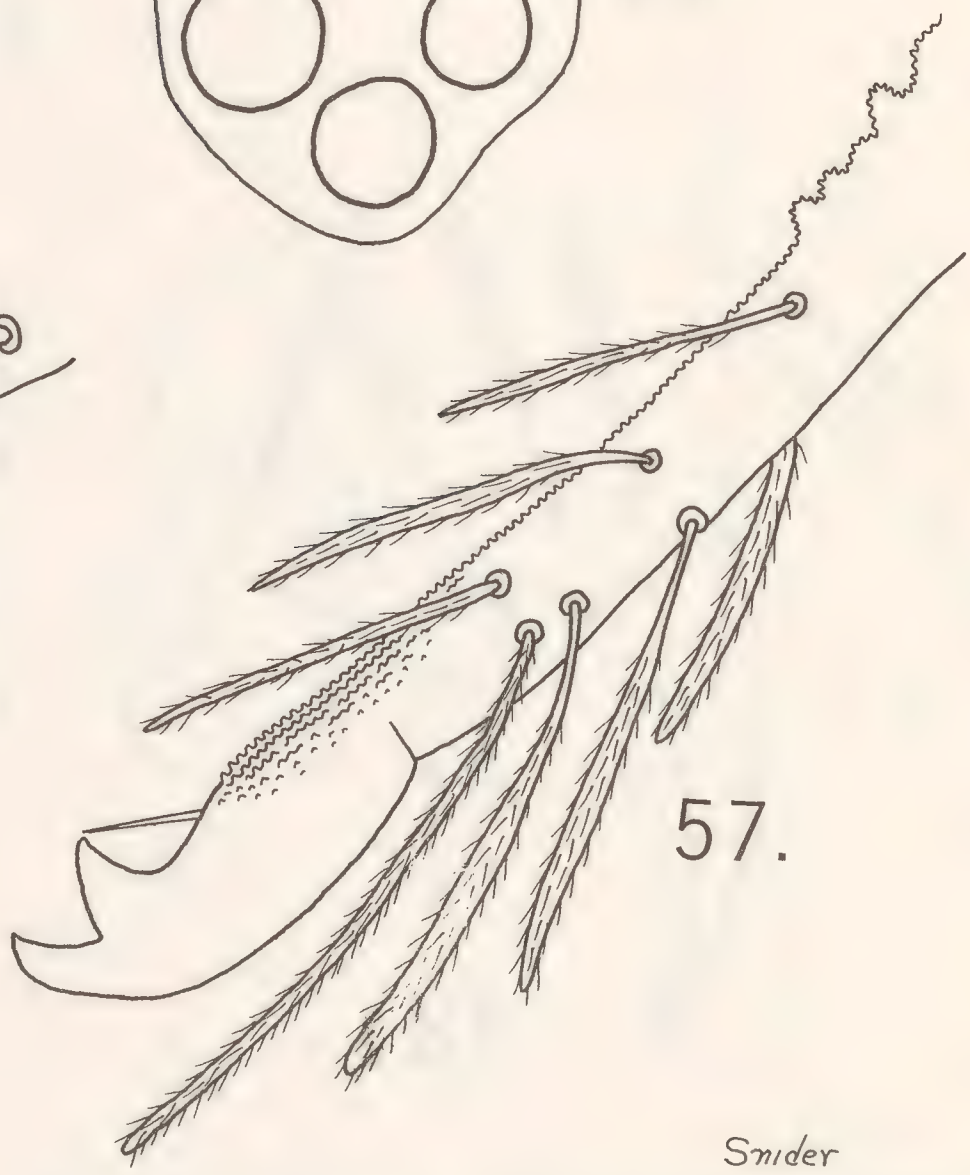

57.

Snider

Lepidocyrtus floridensis n. sp. Fig. 41.--L. floridensis, lateral view habit drawing. Fig. 52.--L. floridensis, dorsal view habit drawing. Fig. 53.--Tenaculum with seta. Fig. 54.--Antenna. Fig. 55.--Eye patch of left side of head. Fig. 56.--Right claw of third leg. Fig. 57.--Mucro.